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U.S. Merchandise Trade Projections

This article presents two equations, one for exports and one for imports, which serve as the main tools for short-term trade projections in the BEA Balance of Payments Division. The equations mainly concentrate on the effects of cyclical changes in foreign and domestic business activity. The equations are useful in the preparation of projections, but the equation results must be modified by judgment concerning the impact of many trade developments that cannot be explained fully by regression analysis because they are related to events for which there is little or no quantitative historical experience.

THIS article discusses procedures used by the Balance of Payments Division, Bureau of Economic Analysis, to prepare short-term projections of U.S. merchandise exports and imports. As the trade accounts are by far the largest of the balance of payments entries, such projections are of great importance in assessing the balance of payments outlook.

The focus of this article is on the two equations, one for exports and one for imports, which serve as the main tools for trade projections. The equations are based on a theoretical structure that is demand-oriented, and they primarily concentrate on the effects of cyclical changes in foreign and domestic business activity and related price movements. The equations cannot be expected to project the effects of developments that are not within the range of experience in the periods covered by the equations; the effects of such factors must be estimated by other methods. This applies particularly to the widespread changes in foreign exchange rates that occurred from May to December 1971.

The introduction discusses the background and orientation of the work. This is followed by a brief discussion of the considerations involved in choosing the variables included in the equations. Finally, the specifications and performance of the two equations are described in detail.

Introduction

Research by the Balance of Payments Division on the development of forecasting equations for U.S. merchandise exports and imports was begun several years ago. The formulation of the equations has benefited substantially from the ideas of staff members of various Government agencies concerned with the U.S. balance of payments.

The primary purpose of the equations is to produce short-term (1 to 2 years) quarterly projections of U.S. merchandise exports and imports in current dollars. The equations also provide a framework for studying the effects on trade of hypothetical cyclical conditions here and abroad. For example, the equations can be used to estimate exports and imports that could be expected if economic growth, here and abroad, was at the maximum sustainable rate. The results can then be compared with exports and imports that actually occurred.

Although the equations are useful in the preparation of projections, there are many trade developments that cannot be explained adequately by regression analysis because they are related to events for which there is little or no quantitative historical experience. Therefore, in making a projection, the estimates obtained from the equations must be modified by practical judgments concerning the impact of these other factors.

Before the explanatory variables used in the equations were chosen, numerous economic relationships were tested, concentrating particularly on variables for which satisfactory historical series were available on a quarterly basis and for which forecasts could be readily constructed. Not only were equations using total exports and total imports tested, but, to a limited extent, also equations which disaggregated exports and imports by broad geographic areas and commodity groups. The disaggregated equations provide useful insights into the changing structure of international trade, but they generally re-

Table 1.—Contribution of Changes in Explanatory Variables to Changes in Calculated Exports, 1970 and 1971

[Millions of dollars]

Variable	Increase in exports (+); decrease (−)	
	Change from:	
	1969–70	1970–71
Change in calculated exports in 1963 dollars resulting from change in:		
Foreign industrial production (FIP)	1,050	870
Foreign capacity pressure (if UFC)$_{t-1}$	100	−805
U.S. imports (M_{t-1}/P_{mt})	110	345
Price ratio (P_{mt}/P_t)	275	320
Time trend (T)	−310	−410
Dummy (D)	125	−135
Total change in calculated exports in 1963 dollars	1,050	285
Change in calculated exports resulting from change in price deflator (P_{xt})	*1,310*	*1,090*
Total change in calculated exports in current dollars	*2,360*	*1,375*

quire the use of narrowly defined explanatory variables that are considerably more difficult to forecast than the more broadly based variables that can be used in projecting overall exports or imports. Disaggregated equations are also more vulnerable to random movements that are frequently offsetting in aggregated equations.

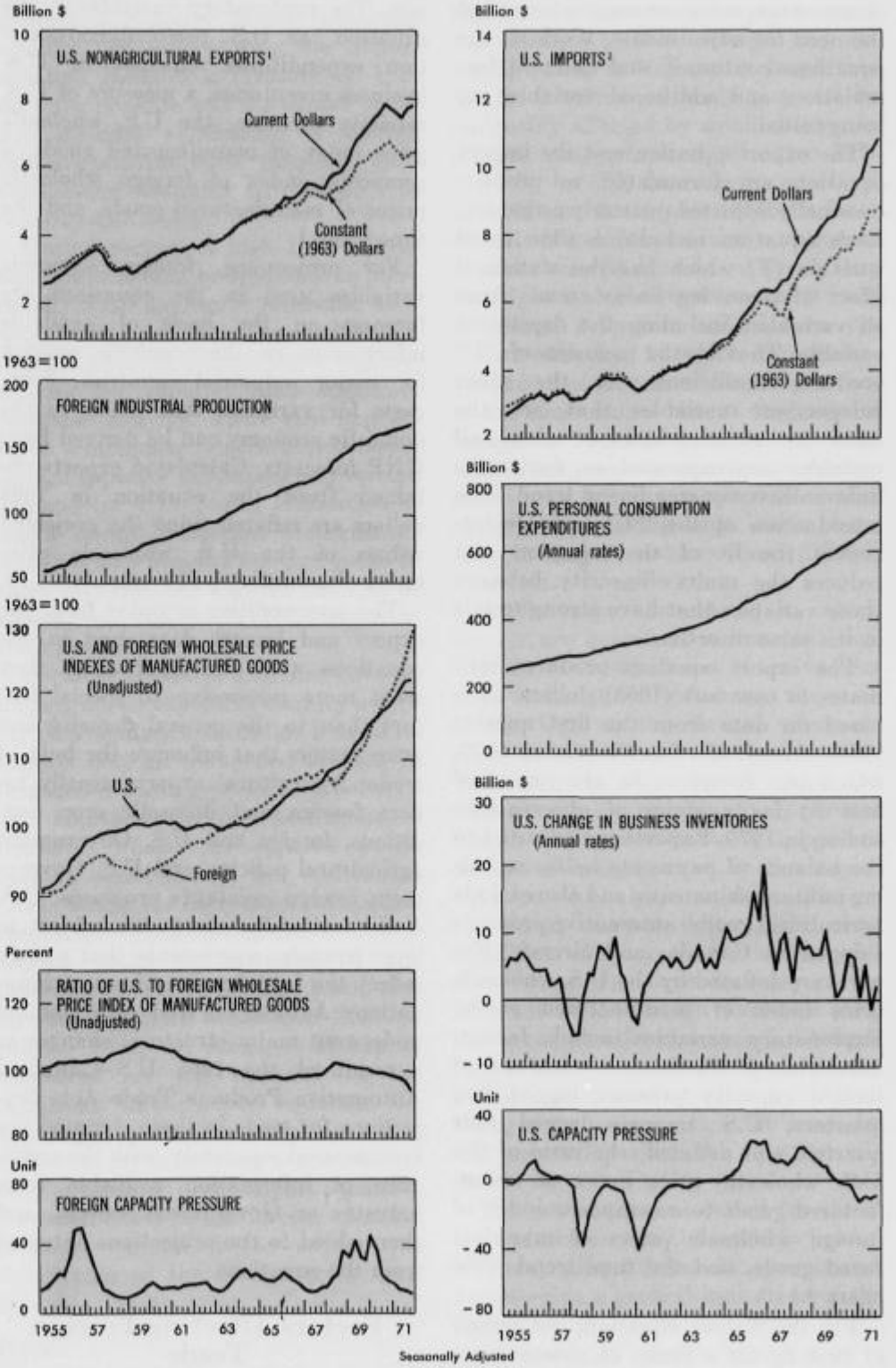
In order to identify properly the structural relationships between exports, imports, and their explanatory variables, it is necessary to remove distortions in the data that are caused by large temporary disturbances such as strikes, insofar as such effects can be reasonably quantified. For instance, exports and imports tend to rise just before a strike occurs, drop during the strike, and then temporarily rise very sharply immediately after the strike. Such distortions tend to obscure the underlying developments and must be taken into account in developing the equations and in making forecasts. The equations, therefore, were fitted using data (for exports, imports, and explanatory variables) that were adjusted to remove distortions resulting from major strikes and other temporary extraordinary events. The adjustments were made by smoothing the irregular movements in the pertinent statistical time series. In some cases, this resulted in adjusted series that add to the same total as actual series. In other instances, the smoothing resulted in omissions from the data of large, nonrepetitive transactions (such as the steel import bulge arising from threats of a domestic steel strike) or in additions to the data (such as estimated losses from strikes). (Further information on the special adjustments applied to the data used in the equations is available upon request. See the note at the end of the article.)

Current equations

The two equations discussed in this article are the most satisfactory of those that have been explored by the Balance of Payments Division to date. The performance of the export equation has been relatively satisfactory; the import equation is less reliable. The equations have deliberately been kept relatively simple so that forecasts can be revised

CHART 9

Variables Used in the Export and Import Equations



1. On the balance of payments basis, excluding military shipments. Data also exclude exports of automotive products to Canada and of aircraft and are adjusted to exclude effects of strikes and other temporary aberrations.

2. On the balance of payments basis, excluding military shipments and imports of Canadian automotive products. Imports in 1963 dollars (as used in the export equation) are adjusted to smooth out fluctuations due to U.S. longshoremen's strikes. Imports in current dollars (as used in the import equation) are adjusted to remove major distortions due to domestic strikes and other temporary disturbances.

Note.– For definition of variables, see text.

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and updated frequently and quickly without the use of complicated techniques. The equations are subject to change as evolving circumstances reveal the need for adjustments. Work on the equations continues, and different formulations and additional variables are being tested.

The export equation and the import equation are formulated to produce seasonally adjusted quarterly estimates. Each equation includes a time trend variable (T) which has the statistical effect of removing linear trends from all variables, including the dependent variable. That is, the inclusion of "T" produces coefficients for the other independent variables that are the same as those obtained when all variables are expressed as deviations from a least squares linear trend. The introduction of the "T" variable improves the fit of the equation and reduces the multicollinearity between those variables that have strong trends in the same direction.

The export equation produces estimates in constant (1963) dollars. It is based on data from the first quarter 1956 through the fourth quarter 1970, which was found to be the period of best fit for a series of observations ending in 1970. Exports are adjusted to the balance of payments basis, excluding military shipments, and also exclude agricultural goods, automotive products shipped to Canada, and aircraft. Exports are deflated by the U.S. wholesale price index of manufactured goods. Explanatory variables include foreign industrial production, a measure of foreign capacity pressure lagged two quarters, U.S. imports lagged four quarters and deflated, the ratio of the U.S. wholesale price index of manufactured goods to a composite index of foreign wholesale prices of manufactured goods, and the time trend. (See chart 9.)

For the import equation, the period of best fit for a series of observations ending in 1970 is the first quarter 1955 through the fourth quarter 1970. The equation produces current dollar estimates. (An acceptable import equation in constant dollars has not yet been developed.) Imports are adjusted to the balance of payments basis, excluding military shipments, and also exclude automotive products shipped from Canada. The explanatory variables in the equation are U.S. personal consumption expenditures, changes in U.S. business inventories, a measure of U.S. capacity pressure, the U.S. wholesale price index of manufactured goods, a composite index of foreign wholesale prices of manufactured goods, and the time trend.[1]

For projections, foreign economic variables used in the equations are forecast on the basis of available information on the economic outlook for major industrial countries. Forecasts for variables that relate to the domestic economy can be derived from GNP forecasts. Calculated exports obtained from the equation in 1963 dollars are reflated using the projected values of the U.S. wholesale price index of manufactured goods.

The commodities excluded from the export and import data used in the equations were omitted because they seem more responsive to special factors than to the general demand and price factors that influence the bulk of trade. Agricultural exports usually reflect foreign and domestic crop conditions, foreign and U.S. Government agricultural policies, and U.S. Government foreign assistance programs. U.S. civilian aircraft exports are subject to large irregular movements that mainly reflect the introduction of major innovations. Automotive trade with Canada underwent major structural changes as a result of the 1965 U.S.–Canadian Automotive Products Trade Act. Projections for trade in these commodities are prepared separately, with the assistance of information available from industry or Government sources, and then added to the projections obtained from the equations.

Factors Affecting Foreign Trade

This section briefly reviews factors affecting foreign trade that were considered in choosing the variables for the export and import equations.

Fluctuations in U.S. exports primarily reflect economic conditions in the importing countries; fluctuations in U.S. imports primarily reflect economic conditions here. To measure these effects, broad indicators such as gross national product, personal consumption expenditures, or industrial production can be used together with indicators of capacity utilization and price movements. Other factors affecting trade patterns that are more difficult to quantify include changes in quality of goods, in technology, in tariffs or other trade barriers, and in consumer tastes. Moreover, trade movements are often distorted by unexpected economic, social, or political developments. Such distortions are usually limited to a relatively short period, but occasionally result in permanent changes in trade patterns.

Economic activity

Deviations of imports from their longer run trends tend to mirror the cyclical movements of demand in the importing country. Import growth accelerates in periods of economic recovery and slows in recessions. Gross national product (GNP)—the market value of total output of goods and services—is the most comprehensive measure of economic activity. However, the relative weights of the various components of the GNP do not necessarily reflect the importance of their influence on imports. Demand for imported consumer goods could be expected to be related to the personal consumption expenditures component of GNP. Industrial production indexes mainly measure the output of manufactures, and could be expected to be particularly relevant in explaining demand for imported industrial materials and capital goods.

As it turns out, personal consumption expenditures (for goods and services) seem to be the most effective variable for representing U.S. demand as a determinant of U.S. imports. This presumably reflects the fact that consumer goods and the materials and components used in their production

1. Donald Curtis, U.S. Treasury Department, made major contributions to the formulations of the foreign and U.S. capacity pressure measures and the foreign wholesale price index.

comprise the major part of imports. Although imports of capital goods have been rising, and some imported industrial materials and components are used in domestic capital goods production, the addition of a separate variable such as private domestic investment to represent the demand for imported capital goods did not produce results significant enough to justify inclusion of the variable in the import equation.

Another GNP component—change in business inventories—has been included in the import equation to reflect changes in imported goods that may be more immediately responsive to changes in demand resulting from inventory accumulation or liquidation than to current changes in personal consumption expenditures. However, this variable may also represent cyclical variations in overall economic activity.

In the export equation, foreign industrial production is used to represent demand for U.S. nonagricultural exports. The decision to use foreign industrial production rather than foreign GNP was partly governed by the timely availability of quarterly data; GNP data for many foreign countries are on an annual basis and not readily and quickly available. Industrial production abroad seems to relate closely to U.S. exports in the same quarter. However, exports tend to continue upward in quarters immediately following cyclical peaks in foreign industrial production and in certain other cases when expansion of foreign industrial production initially decelerates. A dummy (D) is included in the equation with a value of one in the pertinent quarters to explain the faster than expected export growth.

U.S. imports lagged four quarters and deflated by the U.S. wholesale price index of manufactured goods are also included in the export equation as a proxy for foreign demand for U.S. goods generated by U.S. economic activity. (The larger the foreign exchange earnings of foreign countries resulting from previous export sales to the United States, the greater is their demand for U.S. exports.)

Pressures on capacity

Demand for imported goods seems to be related nonlinearly to utilization of productive capacity in the importing country. To reflect this, the import equation includes a measure of U.S. capacity pressure and the export equation includes a measure of foreign capacity pressure, both "pressure" variables being nonlinear with respect to capacity utilization.

During periods of high U.S. utilization, imports tend to expand even more rapidly than aggregate economic activity; during periods of low utilization, imports tend to decline more rapidly, or rise less rapidly, than aggregate economic activity. There also appears to be a nonlinear relationship between foreign capacity utilization and foreign demand for U.S. goods. Utilization in major foreign industrial countries affects not only demand for U.S. goods in those countries but also the strength of competition faced by U.S. exports in third markets.

Capacity pressures may also have an impact on an exporting country's supply. If a country's utilization is high, its exports may be dampened because of lengthened waiting periods for delivery and tendencies to give preference to domestic orders; the opposite would hold in conditions of low utilization. (Also, during the early stages of cyclical recoveries—when utilization is low—exports could be bolstered by the favorable effects that rising productivity has on unit costs and thus on prices.) However, measures of supply influences are not included in the equations. In the export equation, the U.S. capacity pressure variable, used to reflect supply influences, is not statistically significant; in the import equation, the main effect of the foreign capacity pressure variable is to reduce the significance of the foreign price variable.

Prices

A decrease in the ratio of domestic to foreign prices theoretically should have a stimulative effect on the volume of exports and a dampening affect on the volume of imports. However, it is hard to find a strong relationship in the data. One problem is the lack of appropriate price indicators for internationally traded goods. Another problem is that for a number of commodities the gap between the absolute level of foreign and domestic prices is sufficiently large that the total volume of trade may not be noticeably affected by small changes in relative movements of prices as indicated by broadly based index numbers. In addition, the impact on the volume of trade of a shift in relative movements of prices may be distributed over a long period, and this sort of impact is hard to isolate. A further difficulty for the import equation, in which imports are denominated in current dollars, is that in the short run a rise in the ratio of foreign to domestic price indexes that reflects an absolute increase in foreign prices may initially increase the value of imports, making any longer term drop in import volume more difficult to isolate.

In the export equation, in which exports are expressed in constant dollars, the most significant of the various price formulations tested was the ratio of the U.S. to the foreign wholesale price index of manufactured goods. This suggests that exports show the same sensitivity, roughly, to a 1 percent rise in U.S. price as to a 1 percent decline in foreign prices. In the import equation, in which imports are expressed in current dollars, the most significant of the various price formulations tested was separate entry of the U.S. and of the foreign wholesale price indexes of manufactured goods. Changes in the U.S. price index appear to have a much greater effect on imports than changes in foreign price, at least for the periods for which the equation was fitted.

The price indexes selected for use in the equations—the U.S. and the foreign wholesale price indexes of manufactured goods—give a general indication of the theoretically expected trends. These indexes are not specifically measures of the prices of U.S. exports or U.S. imports, but only proxies for the general trend of prices here and abroad. (The foreign price indexes are adjusted to include the changes resulting from foreign currency revaluations relative

to the U.S. dollar: foreign currency depreciations tend to reduce foreign prices vis-a-vis U.S. prices; foreign currency appreciations tend to increase foreign prices.) Available measures of prices of U.S. exports and imports—the unit value indexes—were not used because they have a limited coverage of manufactured commodities and they reflect changes in commodity mix as well as changes in prices. In addition, the unit value indexes are difficult to project because they do not appear to have consistent relationships with other available economic indicators.

Other factors

Among other factors that affect trade, the only one studied very thoroughly was the effect on imports of changes in U.S. tariffs. The most successful formulation used was the ratio of U.S. duty collections to total imports (excluding Canadian automotive products). The ratio does not appear to have been noticeably influenced by tariff changes until the introduction of across-the-board tariff reductions resulting from the "Kennedy round" of GATT negotiations. Those reductions were effective in five stages beginning January 1, 1968, and ending January 1, 1972. However, the duty collection variable adds little of significance to the import equation and is omitted in the equation discussed in this article.

The Export Equation

The export equation is based on quarterly, seasonally adjusted data from the first quarter 1956 through the fourth quarter 1970. Exports are expressed in constant (1963) dollars. For projections, exports calculated from the equation are converted into current dollars by multiplying them by the projected U.S. wholesale price index of manufactured goods. The equation has the following specification:*

$$NX/P_{us} = \underset{(6.86)}{3{,}604.67} + \underset{(12.73)}{48.54}\ FIP + \underset{(5.18)}{8.30}\ (1/UFC)_{t-2} + \underset{(3.78)}{0.14}\ M_{t-4}/P_{us} - \underset{(7.62)}{38.39}\ P_{us}/P_f - \underset{(7.04)}{38.10}\ T + \underset{(3.39)}{126.18}\ D$$

The numbers in parentheses are "t" ratios (ratios of regression coefficients to their standard errors). The coefficient of determination corrected for degrees of freedom ($\bar{R}^2$) is 0.995; the Durbin-Watson statistic (D.W.) is 1.90; the corrected standard error of the estimate (S_e) is 74; and the corrected standard error of the estimate divided by the mean of the dependent variable ($\bar{S}_e$) is 1.71.

Variables:

NX—U.S. nonagricultural exports, excluding automotive products shipped to Canada and aircraft, seasonally adjusted quarterly rates in millions of dollars. The data are on the balance of payments basis, excluding military shipments, and are adjusted to remove distortions due to major domestic strikes and other important identifiable temporary disturbances.

P_{us}—U.S. wholesale price index of manufactured goods, 1963=100.

FIP—Foreign industrial production index, 1963=100. The index is a composite of seasonally adjusted industrial production indexes for Canada, Japan, United Kingdom, and continental Western Europe, weighted by the annual shares of these areas in U.S. exports. The index for continental Western Europe is derived from indexes for Germany, France, Italy, and the Netherlands weighted by the 1963 values of their gross domestic products.

UFC_{t-2}—Unutilized foreign industrial capacity lagged two quarters [UFC=1−(FIP/FC)]. The calculation of foreign capacity (FC) is explained below.

M_{t-4}—U.S. imports, excluding Canadian automotive products, lagged four quarters, seasonally adjusted quarterly rates in millions of dollars. The data are on the balance of payments basis, excluding military shipments, and are adjusted to smooth out irregular movements due to U.S. dockworkers' strikes.

P_f—Foreign wholesale price index of manufactured goods, 1963=100. The index is a composite of the wholesale price indexes of manufactured goods for Canada, Japan, United Kingdom, Germany, France, Italy, the Netherlands, and Belgium, weighted by each country's share in the group's total exports of manufactured goods in the preceding year. The price data are adjusted to include changes resulting from foreign currency revaluations relative to the U.S. dollar. These adjustments are entered gradually over a four-quarter period following the revaluation.

T—Linear time trend, first quarter 1955=1.

D—Dummy variable with a value of 1 is used in all quarters when foreign industrial production (FIP) declines and in all quarters when expansion of FIP first slows to less than 0.4 of an index point following periods of faster increase.

The foreign capacity index (FC) used in the calculation of the measure of foreign capacity pressure is computed from the composite foreign industrial production index. For the period from the first quarter 1954 through the fourth quarter of 1970, a straight line was fitted to the logarithms of the foreign industrial production index. The highest 25 percent of the observations, in terms of deviations from the trend line, was isolated. A trend line was then fitted to those observations. The level of that trend line was raised by 2 percent and the resulting trend line was used to represent the index of foreign industrial capacity. The procedure that was followed ensured that the foreign industrial production index would never exceed the foreign industrial capacity index. Several formulations of the capacity pressure variable were tried in the export equation. The reciprocal of unutilized capacity, lagged two quarters, proved to be the most significant measure. This capacity pressure variable increases at a sharply accelerating rate as unutilized capacity approaches zero, and decreases at a sharply decelerating rate as unutilized capacity increases.

* An equation expressed in current dollars that performs somewhat less satisfactorily has the following specification:

$$NX = \underset{(0.23)}{151.31} + \underset{(13.94)}{42.52}\ FIP(P_f) + \underset{(5.59)}{9.72}\ (1/UFC)_{t-2} + \underset{(2.44)}{0.10}\ M_{t-4} - \underset{(0.07)}{0.42}\ P_{us}/P_f - \underset{(6.21)}{27.10}\ T + \underset{(2.00)}{115.16}\ D$$

The $\bar{R}^2$ is 0.997; D.W. is 1.71; $\bar{S}_e$ is 74; and $\bar{S}_e$ is 1.77.

Table 2.—Actual and Calculated Values of U.S. Nonagricultural Exports

[Seasonally adjusted]

	Total [1]	Exclusions: Autos to Canada, aircraft, and agricultural goods	Adjustments	Exports minus exclusions plus adjustments					
				Actual	Calculated (refitted)	Actual minus calculated (refitted)	Actual	Calculated	Actual minus calculated
	Billions of current dollars						Billions of 1963 dollars		
1956–I	3,545	984		2,561	(3)	(3)	3,514	(3)	(3)
II	3,450	958		2,502	(3)	(3)	3,342	(3)	(3)
III	3,695	975		2,720	(3)	(3)	3,657	(3)	(3)
IV	3,734	903		2,831	(3)	(3)	3,844	(3)	(3)
1958–I	3,975	1,018		2,956	2,991	−35	3,155	3,186	−31
II	4,296	1,154		3,143	3,137	6	3,278	3,267	11
III	4,513	1,252		3,261	3,172	89	3,404	3,311	93
IV	4,709	1,305	−109	3,304	3,344	−40	3,410	3,451	−41
1957–I	5,100	1,452	−260	3,448	3,507	−59	3,522	3,582	−60
II	5,021	1,314	−140	3,567	3,509	58	3,632	3,573	59
III	4,884	1,255		3,629	3,541	88	3,640	3,584	56
IV	4,527	1,137		3,390	3,363	27	3,428	3,400	28
1958–I	4,140	1,089		3,051	3,144	−93	3,073	3,167	−94
II	4,052	1,127		2,925	2,995	−70	2,963	3,034	−71
III	4,112	1,148		2,964	2,985	−21	2,979	3,000	−21
IV	4,060	1,062		2,998	2,962	76	3,037	2,961	76
1959–I	3,858	894		2,964	2,959	−55	2,881	2,955	−86
II	3,977	1,059		2,918	2,987	−69	2,903	2,974	−71
III	4,276	[2] 1,318	−76	3,033	3,067	45	3,071	3,026	45
IV	4,217	[2] 1,367	351	3,200	3,197	5	3,194	3,191	3
1960–I	4,094	1,424		3,270	3,310	−40	3,254	3,293	−39
II	4,216	1,427	−100	3,389	3,369	20	3,372	3,352	20
III	4,332	1,438	−100	3,494	3,401	93	3,448	3,374	74
IV	4,418	1,521		3,497	3,427	70	3,453	3,413	70
1961–I	5,095	1,809	−25	3,261	3,470	91	3,536	3,446	90
II	4,309	1,376	50	3,478	3,525	−47	3,478	3,525	−47
III	5,087	1,417	−60	3,570	3,596	−26	3,577	3,603	−26
IV	5,199	1,475		3,691	3,618	73	3,695	3,622	73
1962–I	5,077	1,467		3,650	3,689	−39	3,613	3,662	−49
II	5,295	1,555		3,740	3,723	27	3,746	3,719	27
III	5,332	1,481		3,851	3,819	32	3,890	3,807	32
IV	5,096	[2] 1,450	200	3,766	3,963	−178	3,781	3,959	−178
1963–I	5,066	[2] 1,540	309	3,818	3,853	−35	3,826	3,871	−45
II	5,403	[2] 1,585	−100	3,808	3,848	−40	3,815	3,855	−40
III	5,566	1,418		4,045	4,035	13	4,040	4,027	13
IV	5,936	1,725		4,210	4,201	9	4,197	4,188	9
1964–I	6,238	[2] 1,758	−80	4,398	4,318	80	4,347	4,296	51
II	6,127	[2] 1,766	−20	4,411	4,448	−37	4,400	4,440	−40
III	6,417	1,828	−50	4,541	4,507	34	4,518	4,485	33
IV	6,631	[2] 1,825	−165	4,641	4,617	24	4,604	4,580	24
1965–I	6,670	[2] 1,576	805	4,608	4,622	45	4,613	4,567	45
II	6,884	[2] 1,928	−226	4,680	4,713	−33	4,695	4,625	−31
III	6,357	2,077	−30	4,750	4,772	−22	4,638	4,661	−21
IV	6,999	2,044		4,955	4,895	60	4,777	4,748	29
1966–I	7,223	2,094		5,129	5,049	80	4,952	4,862	90
II	7,191	2,117		5,074	5,165	−91	4,842	4,928	−86
III	7,413	2,278		5,135	5,259	−124	4,858	4,975	−117
IV	7,563	2,299		5,259	5,272	−4	4,990	4,993	−3
1967–I	7,603	2,176		5,617	5,387	130	5,216	5,092	123
II	7,719	2,261		5,488	5,280	188	5,188	4,998	178
III	7,669	2,294		5,375	5,392	−17	5,056	5,072	−16
IV	7,999	2,274	25	5,398	5,547	−197	5,014	5,199	−185
1968–I	7,947	2,474	240	6,713	5,595	118	5,200	5,181	109
II	8,385	2,499	−125	6,761	5,736	28	5,305	5,281	24
III	8,378	[2] 2,557	−595	5,815	5,866	−50	5,333	5,377	−45
IV	8,378	[2] 2,547	330	6,161	6,266	−105	5,621	5,717	−96
1969–I	7,510	[2] 2,588	1,600	6,525	6,497	28	5,278	5,353	25
II	9,480	[2] 2,392	−800	6,703	6,662	−94	6,064	5,139	−75
III	9,003	2,818		6,964	6,958	26	6,181	6,156	25
IV	9,328	2,711		7,177	7,220	−43	6,285	6,322	−37
1970–I	10,241	2,750		7,491	7,396	95	6,475	6,393	82
II	10,462	2,962		7,500	7,530	70	6,528	6,459	69
III	10,699	2,851		7,845	7,878	−33	6,665	6,716	−26
IV	10,451	2,755		7,696	7,715	−20	6,527	6,544	−17
1971–I	11,616	3,418		7,526	[4] 7,311	−213	6,574	[4] 6,553	−179
II	10,706	3,272		7,434	[4] 7,810	−376	6,188	[4] 6,492	−312
III	11,476	[2] 3,268	−800	7,512	[4] 8,049	−407	6,255	[4] 6,589	−334
IV	9,672	[2] 3,187	1,390	7,895	[4] 8,252	−557	6,316	[4] 6,793	−666

1. Balance of payments basis, excluding military shipments.
2. The equation for nonagricultural exports begins in the first quarter of 1956.
3. Agricultural exports are adjusted for U.S. dockworkers' strikes and in 1964 I and II for extraordinary shipments of wheat to U.S.S.R.
4. Equation ends in the fourth quarter of 1970; 1971 data are projections.

Contributions of explanatory variables

In the export equation the foreign industrial production index is the most significant explanatory variable as indicated by the "t" ratio. The other variables in descending order of statistical significance are the price ratio, the time trend, foreign capacity pressure, imports, and the dummy.

The impact of changes in the explanatory variables on changes in calculated exports depends upon the size of each variable's regression coefficient and the amount of change in each variable, which varies from period to period. For the years 1970 and 1971, the contribution of variables to the total change in exports is shown in table 1. The amount of change in calculated exports contributed by each explanatory variable was obtained by multiplying the actual quarterly values of each explanatory variable by its regression coefficient, then summing the quarterly values to annual totals, and calculating the differences between years.

Performance of the export equation

The export equation performs quite well during the period to which it is fitted, i.e., first quarter 1956 through fourth quarter 1970 (see chart 10 and table 2).

In only three out of the 60 observations included in the equation did actual and calculated exports differ by more than two standard errors. In those periods, the differences may have been due to the difficulties in adjusting the data for the effects of special developments. The overestimate of $178 million in the fourth quarter 1962 may have reflected an insufficient adjustment to actual exports for effects of a dock strike. In the second quarter 1967 there was an underestimate of $178 million, followed in the fourth quarter of 1967 by an overestimate of $185 million. These differences may have been associated partly with the trade disruptions resulting from the closure of the Suez Canal in late May 1967.

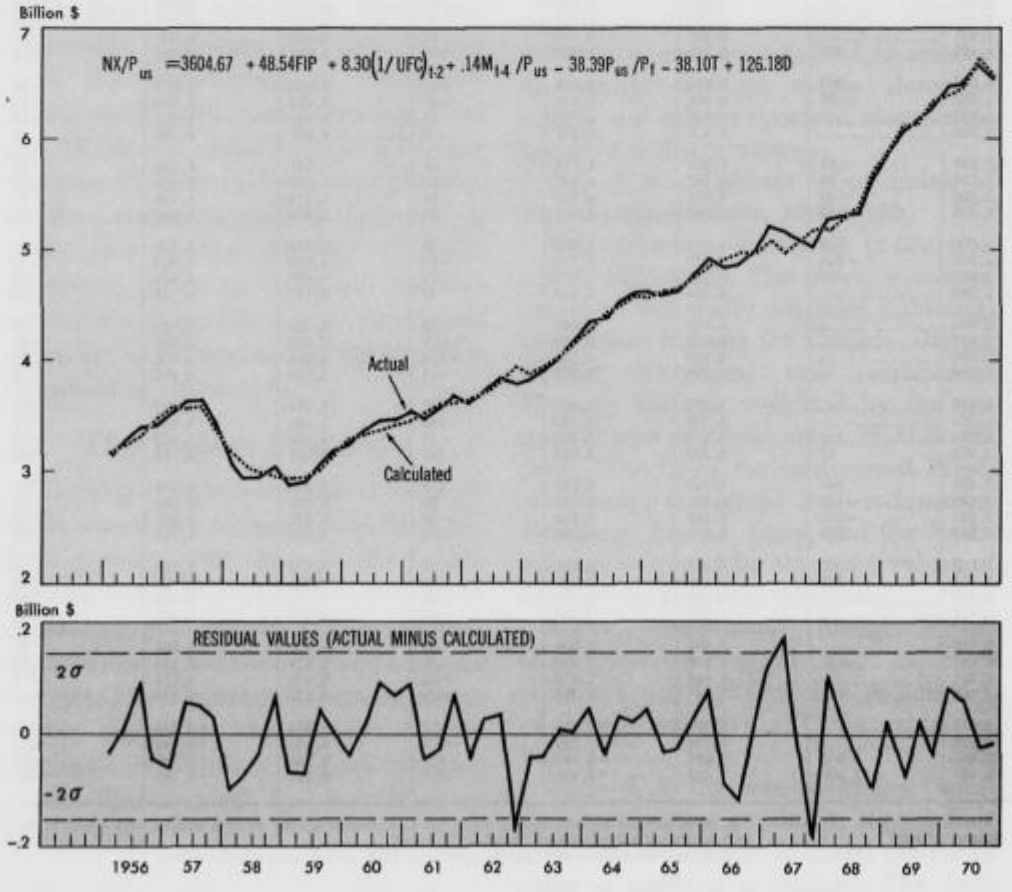
The characteristics of the export equation do not change markedly when the period to which it is fitted is changed (table 3). The coefficients are relatively stable and statistical measures remain significant in equations beginning in 1955 or 1956 and ending in any one of the years 1967–70. In equations beginning in 1957, the "t" ratios for most of the variables are poorer and in two instances are below statistically significant levels.

To test how well the equations would forecast, they were solved for the quarters beyond the periods to which they were fitted, using the actual values of the explanatory variables in those quarters. The resulting calculated exports were then compared with actual export values. Table 3 shows the annual error at a quarterly rate (actual less calculated) resulting from projections of the equations made for 1 year beyond the period of fit. (Projections made for more than 1 year beyond the period of fit are not shown in table 3 but are available upon request.)

The export equations covering the periods beginning in 1956 and ending in 1967, 1968, and 1969 produce forecasts 1 year ahead with annual errors at a quarterly rate ranging from −$30 million to +$45 million (−0.6 to +0.7 percent of actual exports). The equations beginning in 1956 and ending in 1967 and 1968 produce forecasts for the second year beyond the period of fit—1969 and 1970, respectively—with annual errors at a quarterly rate of −$63 million and +$37 million (−1.0 and

CHART 10

Actual and Calculated Values of U.S. Nonagricultural Exports and Residuals, in 1963 Dollars



NOTE:—Exports are on the balance of payments basis excluding military shipments. Data also exclude exports of automotive products to Canada and of aircraft, and are adjusted to exclude effects of strikes and other temporary aberrations.

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+0.6 percent). All of these equations as well as the one for the period beginning in 1956 and ending in 1970 sharply overestimate 1971 exports with annual errors at a quarterly rate ranging from −$304 million to −$340 million (−4.8 to −5.4 percent). The large forecasting errors for 1971 are probably due for the most part to the adverse impact on exports of unsettled international financial conditions and of strikes or threats of strikes that prevailed during most of the year. However, it should be noted that the values now available for the explanatory variables for 1971 are still uncertain and adjustments for strike effects are based on incomplete information. These data may be revised and the overestimate may be reduced. (The equation fitted through 1969, for instance, predicted 1970 exports with an error of 2.0 percent using data available in May 1971 for the explanatory variables; it predicted 1970 exports with an error of 0.7 percent using data available in May 1972.)

The Import Equation

The import equation is based on quarterly, seasonally adjusted data from the first quarter 1955 through the fourth quarter 1970. Imports are expressed in current dollars. The equation has the following specification:

$$M = -7{,}558.73 + 23.65\ PCE + 11.02\ CBI + 6.45\ CPSQ + 57.88\ P_{us} - 8.85\ P_f - 58.86T$$
(11.63) (32.50) (3.33) (5.50) (8.91) (1.44) (22.25)

The numbers in parentheses are "t" ratios. The coefficient of determination corrected for degrees of freedom ($\bar{R}^2$) is .999; the Durbin-Watson statistic (D.W.) is 1.76; the corrected standard error of the estimate ($\bar{S}_e$) is 75; and the corrected standard error of the estimate divided by the mean of the dependent variable ($\bar{S}_p$) is 1.51.

It might be desirable to construct the import equation in constant dollars to parallel the export equation. Thus far, a constant dollar import equation that produces forecasts with the same or less error than the current dollar equations has not been developed.[3]

Variables:

M—U.S. imports, excluding Canadian automotive products, seasonally adjusted quarterly rates in millions of dollars. The data are on the balance of payments basis, excluding military shipments, and adjusted to remove distortions due to major domestic strikes and other important identifiable temporary disturbances.

PCE—U.S. personal consumption expenditures (including goods and services) as measured in GNP, in billions

3. One version yielded the following:

$$M/P_f = -14{,}090.41 + 32.94\ \text{Deflated PCE} + 11.37\ \text{Deflated CBI} + 0.69\ \text{CPSQ} + 125.93\ P_{us} - 36.84\ P_f - 69.39\ T$$
(18.66) (14.66) (1.97) (.80) (13.09) (3.77) (10.63)

$\bar{R}^2$ is .993; D.W. is 0.84; $\bar{S}_e$ is 126; and $\bar{S}_p$ is 2.61.

Omission of the capacity pressure variable (CPSQ) causes very little change in the remaining coefficients or the statistical measures.

Table 3.—Nonagricultural Export Equation Fitted to Various Time Periods

Regression period	Constant	FIP	$(I/UFC)_{t-2}$	M_{t-4}/P_{us}	P_{us}/P_f	T	D	Forecast error 1 year forward (quarterly rate in millions of 1963 dollars)	$\bar{S}_e$	$\bar{S}_p$	$\bar{R}^2$	D.W.
A. Equations beginning in 1955:												
1955-I—70-IV	2,963.38 (8.06)	45.04 (12.76)	10.83 (3.41)	0.12 (3.03)	−30.65 (7.06)	−20.26 (7.11)	121.17 (2.15)	−301	70	1.60	0.995	1.77
1955-I—69-IV	2,141.88 (6.66)	42.80 (10.97)	11.03 (3.46)	.13 (3.80)	−34.76 (7.10)	−29.98 (5.05)	120.36 (2.04)	40	77	1.89	.994	1.76
1955-I—68-IV	2,972.02 (4.91)	43.45 (10.30)	11.37 (3.19)	.13 (3.23)	−30.62 (6.23)	−27.70 (5.45)	125.85 (2.00)	−34	78	1.03	.991	1.69
1955-I—67-IV	1,933.98 (1.57)	51.72 (6.82)	11.39 (7.96)	.10 (2.23)	−23.24 (3.03)	−38.81 (4.19)	150.87 (3.18)	−77	77	2.03	.990	1.55
B. Equations beginning in 1956:												
1956-I—70-IV	3,504.87 (6.55)	48.54 (12.73)	8.30 (5.15)	.14 (3.78)	−28.39 (7.62)	−38.10 (7.04)	136.15 (2.30)	−323	74	1.71	.995	1.08
1956-I—69-IV	3,755.03 (5.77)	46.01 (10.92)	8.59 (5.28)	.15 (3.94)	−29.02 (7.50)	−36.11 (6.82)	128.76 (2.12)	45	75	1.60	.994	1.02
1956-I—68-IV	3,579.62 (5.40)	45.85 (10.21)	8.62 (4.88)	.16 (3.79)	−26.30 (6.47)	−34.54 (5.56)	126.81 (2.08)	−8	77	1.92	.991	1.94
1956-I—67-IV	2,994.51 (2.45)	50.61 (8.48)	9.10 (4.94)	.13 (2.78)	−33.57 (3.70)	−38.43 (4.25)	135.46 (2.10)	−30	77	1.96	.988	1.62
C. Equations beginning in 1957:												
1957-I—70-IV	3,895.17 (5.01)	45.88 (7.95)	9.30 (3.96)	.14 (3.57)	−35.47 (4.73)	−32.91 (3.18)	124.65 (2.28)	−300	74	1.71	.988	1.91
1957-I—69-IV	3,275.45 (4.61)	50.67 (8.06)	10.08 (4.30)	.16 (3.71)	−32.14 (4.05)	−22.83 (1.96)	131.90 (2.13)	61	75	1.78	.994	1.96
1957-I—68-IV	2,942.78 (3.48)	57.64 (8.81)	12.52 (4.25)	.16 (3.47)	−28.35 (3.15)	−18.19 (1.45)	129.63 (2.04)	−19	77	1.89	.991	1.85
1957-I—67-IV	2,650.71 (2.04)	61.40 (4.04)	12.24 (4.06)	.13 (2.69)	−27.04 (2.46)	−23.17 (1.49)	134.67 (2.05)	−6	77	1.05	.988	1.62

NOTE.—Figures in parentheses are "t" ratios.

of dollars at seasonally adjusted annual rates.

CBI—Change in U.S. business inventories as measured in GNP, in billions of dollars at seasonally adjusted annual rates.

CPSQ—Measure of U.S. capacity pressure, derived from the ratio of actual to potential gross national product; the calculation of this variable is explained below.

P_{us}—U.S. wholesale price index of manufactured goods, 1963=100.

P_f—Foreign wholesale price index of manufactured goods, 1963=100. The index is a composite of the wholesale price indexes of manufactured goods for Canada, Japan, United Kingdom, Germany, France, Italy, the Netherlands, and Belgium, weighted by each country's share in the group's total exports of manufactured goods in the preceding year. The price data are adjusted to include changes resulting from foreign currency revaluations relative to the U.S. dollar. These adjustments are entered gradually over a four-quarter period following the revaluation.

T—Linear time trend, first quarter 1955=1.

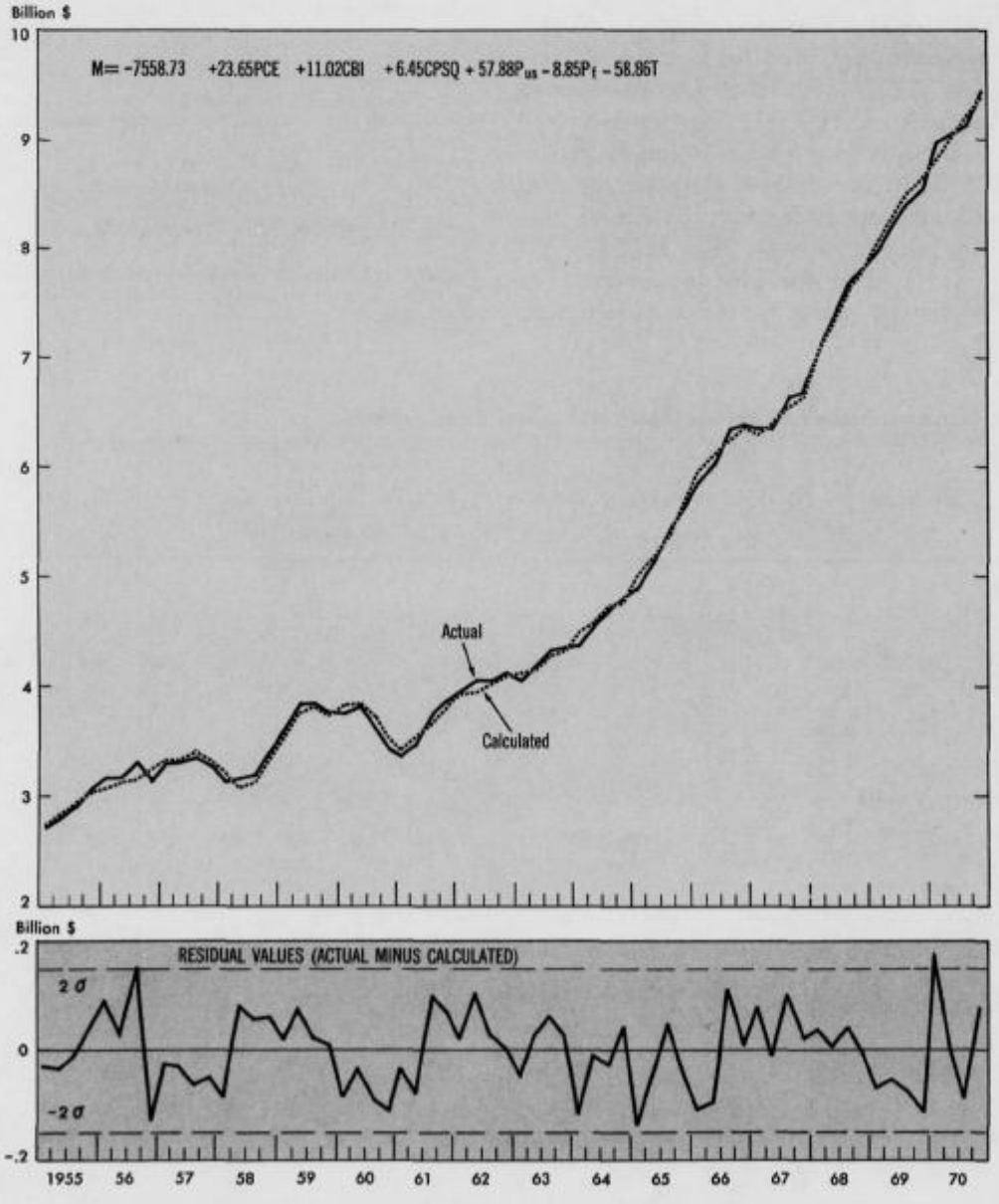
The U.S. capacity pressure measure used in the import equation is calculated as follows: the difference between the ratio of actual to potential GNP and 0.97 is multiplied by 100, then squared and expressed with a positive sign if the ratio of actual GNP to potential GNP is greater than 0.97 and with a negative sign otherwise—

$$CPSQ = (100\ [(\text{Actual GNP/Potential GNP}) - 0.97])^2.$$

The 97-percent figure is the average of the ratio of actual GNP to potential GNP in 1955–70, and is used to represent average capacity utilization. It was chosen after experimentation with a series of ratios ranging from 93 through 98 percent. In this formulation, capacity pressure increases at a sharply accelerating rate as utilization rises above average levels and decreases at a sharply accelerating rate as utilization falls below average. This measure of capacity pressure produces more significant results in the import equation than were obtained using several other formulations including one with a capacity pressure similar to that used in the export equation.

CHART 11

Actual and Calculated Values of U.S. Imports and Residuals



NOTE:—Imports are on the balance of payments basis excluding military shipments. Data also exclude imports of automotive products from Canada and are adjusted to exclude effects of strikes and other temporary aberrations.

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Contribution of variables

In the import equation, U.S. personal consumption expenditures is the most significant explanatory variable as indicated by the "t" ratio. The other variables, in descending order of statistical significance, are the time trend, U.S. price, U.S. capacity pressure, change in U.S. business inventories, and foreign price.

The contribution of changes in the variables to the calculated change in imports depends upon the size of each variable's regression coefficient and on the amount of change in each variable, which may differ in each period. This is shown in table 4 for the years 1970 and

1971. The method of measuring the amount of change in calculated imports contributed by each explanatory variable is the same one used for exports, already described.

Performance of import equation

In the period covered by the equation—first quarter 1955 through fourth quarter 1970—calculated imports were generally quite close to actual imports (chart 11). During the 1957–58 and 1960–61 recessions, downturns of actual and calculated imports coincided; the calculated 1958 upturn was one quarter later than the actual rise, but the equation's timing was correct for the 1961 upturn. During the 1970 recession, neither actual nor calculated imports declined. Import strength in the recent recession reflected the continued (although slower) growth in both personal consumption expenditures and business inventories in 1970, as contrasted with actual declines in both measures in earlier recessions.

The two quarters in which calculated and actual imports differed by more than two standard errors were: (1) the third quarter 1956, when extraordinary coffee deliveries pushed actual imports up sharply (these were largely offset in the following quarter); and (2) the first quarter 1970, when actual imports rose very sharply, partly reflecting aberrations due to effects of actual and anticipated import quotas (imports leveled off in the second quarter).

When the time period to which the equation is fitted is changed, the characteristics of the import equation are fairly stable (see table 6). However, the coefficients of the price variables change considerably and are less significant in equations that begin in 1957.

To test the forecasting reliability of

Table 4.—Contribution of Changes in Explanatory Variables to Changes in Calculated Imports, 1970 and 1971

[Millions of dollars]

Variable	Increase in imports (+); decrease (−)	
	Change from:	
	1969–70	1970–71
Change in calculated imports resulting from change in:		
U.S. personal consumption expenditures (PCE)	3,685	4,130
Change in U.S. business inventories (CBI)	−150	−100
U.S. capacity pressure (CPSQ)	−290	−200
U.S. price (P_{us})	885	900
Foreign price (P_f)	−225	−255
Time trend (T)	−940	−940
Total change in calculated imports	2,965	3,535

Table 5.—Actual and Calculated Values of U.S. Imports

[Billions of dollars, seasonally adjusted]

	Total[1]	Canadian autos	Adjustments	Imports minus Canadian autos plus adjustments		
				Actual	Calculated	Actual less calculated
1955–I	2,716	(*)		2,716	2,749	−33
II	2,802	(*)		2,802	2,836	−33
III	2,919	(*)		2,919	2,929	−10
IV	3,060	(*)		3,060	3,048	12
1956–I	3,174	(*)		3,174	3,080	94
II	3,184	(*)		3,184	3,145	39
III	3,316	(*)		3,316	3,160	156
IV	3,130	(*)		3,130	3,261	−131
1957–I	3,292	(*)		3,292	3,317	−25
II	3,297	(*)	−60	3,297	3,391	−22
III	3,355	(*)		3,355	3,415	−60
IV	3,287	(*)		3,287	3,337	−50
1958–I	3,145	4		3,141	3,226	−85
II	3,175	4		3,171	3,091	80
III	3,208	5		3,203	3,146	57
IV	3,424	6		3,418	3,329	89
1959–I	3,521	4	−20	3,537	3,570	21
II	3,862	4	−45	3,853	3,789	74
III	3,949	7	−105	3,837	3,816	21
IV	3,857	6	−65	3,796	3,784	12
1960–I	3,811	3	−40	3,766	3,864	−98
II	3,854	4	−40	3,810	3,848	−38
III	3,646	3		3,643	3,732	−89
IV	3,432	1		3,432	3,540	−108
1961–I	3,390	2		3,388	3,423	−35
II	3,433	2	50	3,481	3,555	−74
III	3,694	2	−50	3,752	3,654	98
IV	3,893	2		3,890	3,819	71
1962–I	3,969	2		3,967	3,934	33
II	4,074	2		4,072	3,984	188
III	4,109	2	−45	4,062	4,038	24
IV	4,076	2	45	4,118	4,114	4
1963–I	4,050	4	35	4,081	4,126	−45
II	4,214	6	−28	4,188	4,155	33
III	4,366	8		4,357	4,295	62
IV	4,382	11		4,371	4,341	30
1964–I	4,494	16		4,388	4,509	−112
II	4,591	23		4,568	4,575	−8
III	4,736	29		4,707	4,731	−24
IV	4,916	34	−65	4,817	4,769	48
1965–I	4,980	35	250	4,805	5,025	−121
II	5,482	29	−305	5,138	5,180	−42
III	5,564	68	−75	5,431	5,385	46
IV	5,770	92	−55	5,623	5,670	−47
1966–I	6,027	163		5,864	5,972	−108
II	6,165	155		6,010	6,101	−91
III	6,606	220		6,386	6,256	110
IV	6,676	294		6,382	6,368	14
1967–I	6,681	296		6,385	6,286	79
II	6,495	344	245	6,396	6,374	−8
III	6,642	400	490	6,632	6,530	102
IV	7,153	397	−70	6,686	6,658	28
1968–I	7,021	499	−270	7,052	7,013	39
II	8,134	543	−226	7,366	7,354	12
III	8,068	578	−300	7,690	7,645	45
IV	8,441	606	80	7,763	7,760	3
1969–I	7,699	700	1,100	7,980	8,046	−66
II	8,668	732	−600	8,334	8,268	−64
III	9,278	840		8,438	8,508	−70
IV	9,397	864		8,533	8,643	−110
1970–I	9,738	701	50	8,987	8,813	174
II	9,631	947	60	9,034	9,025	9
III	9,892	857		9,135	9,221	−86
IV	10,219	748	−100	9,471	9,392	79
1971–I	10,788	908	−50	9,730	[2] 9,550	178
II	11,787	1,051	−250	10,404	[2] 9,973	431
III	12,015	1,147	−400	10,468	[2] 10,154	314
IV	11,988	1,015	640	10,733	[2] 10,309	423

*Less than $500,000.
1. Balance of payments basis, excluding military shipments.
2. Equation ends in fourth quarter of 1970; 1971 data are projections.

the equations, they were solved for the quarters beyond the period to which they were fitted, using the actual values of the explanatory variables in those quarters. The equations for the periods beginning in 1955 and ending in 1967, 1968, and 1969 produce forecasts 1 year beyond the period of fit with annual errors at a quarterly rate ranging from −$102 million to $148 million (−1.2 to +1.6 percent of actual imports) as shown in table 6. The equations beginning in 1955 and ending in 1967 and 1968 produce forecasts for 1969 and 1970, respectively, with annual errors at a quarterly rate of −$108 million and $32 million (−1.3 and +0.3 percent). However, the forecast errors for 1971 are much larger: the equations beginning in 1955 and ending in 1967, 1968, 1969, and 1970 underestimate actual 1971 imports by annual errors ranging from $331 million to $504 million (+3.2 to +4.8 percent). The exceptional conditions prevailing in 1971 were probably the main causes of the large errors. Anticipations of strikes, fears of imposition of quotas or other controls, and expectations of revaluations of several leading currencies undoubtedly contributed to the extraordinary rise in imports. Revision of the 1971 values of the independent variables used in the import equation will probably be much less important than revisions of the 1971 variables used in the export equation, but the adjustments for strikes and other unusual occurrences may be changed as additional information becomes available. (The equation fitted through 1969 predicted 1970 imports with an error of 1.2 percent using data available in May 1971 for the explanatory variables; it predicted 1970 imports with essentially the same amount of error using revised data available in May 1972.)

NOTE

A technical appendix is available upon request to the Balance of Payments Division, BEA. It contains tables showing (1) the data input to the equations, (2) the identification of all special adjustments applied to U.S. exports, U.S. imports, foreign industrial production indexes, and foreign wholesale price indexes, and (3) the specifications of some of the additional export and import equations that have been tested, including equations in log form. The appendix also includes notes explaining in detail the construction of some of the variables included in the equations.

Table 6.—Import Equation Fitted to Various Time Periods

Regression period	Constant	PCE	GBI	CPSQ	P_{US}	P_f	T	Forecast error 1 year forward (quarterly rate in millions of dollars)	$\bar{S}_e$	$\bar{S}_p$	$\bar{r}^2$	D.W.
A. Equations beginning in 1955:												
1955-I—70-IV	−7558.73 (11.63)	23.55 (32.50)	11.02 (2.33)	6.45 (5.50)	57.58 (8.09)	−8.35 (1.44)	−66.98 (22.25)	333	75	1.51	0.999	1.76
1955-I—69-IV	−6660.50 (8.51)	23.49 (34.47)	11.58 (3.65)	7.31 (5.83)	56.71 (9.27)	−17.16 (2.37)	−65.48 (18.07)	148	70	1.48	.999	1.63
1955-I—68-IV	−7304.90 (8.05)	24.29 (20.75)	12.06 (3.66)	6.20 (4.21)	68.35 (0.29)	−18.63 (1.74)	−60.11 (14.16)	−102	71	1.60	.997	1.70
1955-I—67-IV	−7306.35 (7.28)	24.20 (19.53)	12.58 (3.19)	6.12 (3.91)	68.56 (8.94)	−14.05 (1.36)	−60.46 (12.90)	−4	75	1.74	.995	1.76
B. Equations beginning in 1956:												
1956-I—70-IV	−7138.92 (7.57)	24.33 (18.39)	11.49 (3.25)	6.02 (4.12)	57.26 (4.76)	−9.20 (1.44)	−61.15 (13.03)	335	77	1.51	.998	1.75
1956-I—69-IV	−6726.92 (6.25)	24.78 (20.95)	12.07 (3.66)	6.47 (4.53)	48.82 (4.35)	−19.14 (2.52)	−59.50 (12.28)	168	71	1.47	.998	1.67
1956-I—68-IV	−6384.12 (5.31)	25.53 (19.18)	13.06 (3.76)	5.34 (3.28)	47.31 (4.41)	−16.69 (1.90)	−64.27 (11.87)	−165	72	1.56	.997	1.79
1956-I—67-IV	−6113.44 (4.50)	26.14 (13.51)	13.62 (3.25)	5.21 (3.03)	46.14 (4.06)	−15.66 (1.67)	−66.04 (10.15)	−31	75	1.74	.996	1.76
C. Equations beginning in 1957:												
1957-I—70-IV	−9092.50 (7.84)	20.57 (10.51)	8.71 (2.84)	7.10 (4.92)	78.63 (6.00)	−7.79 (1.80)	−47.52 (6.20)	303	73	1.37	.999	1.72
1957-I—69-IV	−7645.38 (4.77)	22.29 (10.52)	11.79 (3.48)	6.97 (4.00)	66.27 (3.64)	−13.52 (1.72)	−51.30 (5.79)	104	67	1.36	.998	1.48
1957-I—68-IV	−8321.56 (5.25)	22.20 (10.52)	12.31 (3.74)	5.70 (3.65)	76.99 (4.31)	−8.70 (.80)	−54.15 (7.00)	−237	69	1.42	998	1.61
1957-I—67-IV	−9818.22 (4.90)	22.88 (6.90)	13.74 (3.51)	5.49 (3.37)	89.26 (5.88)	−2.75 (.23)	−52.05 (5.22)	38	69	1.57	.999	1.53

NOTE: Figures in parentheses are "t" ratios.